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(54) Combustor swirler with twisted vanes

(57) Pre-mixture forming swirler in gas turbine pre-mixed flame type low NO_x combustor is improved so as to accelerate mixing of fuel and air and to prevent occurrence of flame stagnation and burning of component.

Three-dimensional swirler is constructed such that swirler vane (101a) is twisted from hub side thereof to tip side so that fitting angle (β) of the tip side relative to fuel nozzle (102) center axis (C) is larger than that (α) of the hub side. Thereby, while the angle (α) of the hub side is set smaller so that flame stagnation and burning of components resulted therefrom may be prevented from occurring, the angle (β) of the tip side may be selected so that shearing flow necessary for appropriate mixing of fuel (F) and air (A) is obtained, thus favorable pre-mixing is done, life deterioration due to the burning etc. is prevented and combustion efficiency is enhanced.

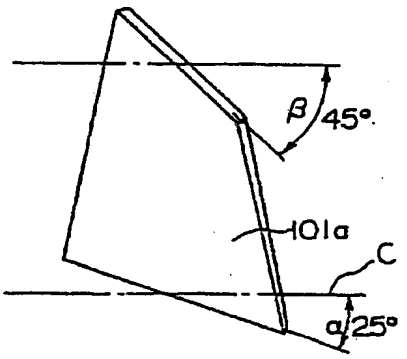

Fig. 1(c)

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Description

BACKGROUND OF THE INVENTION:

Field of the Invention:

[0001] The present invention relates to a swirler for forming a pre-mixture in a pre-mixed flame type low NO_x combustor of gas turbine.

Description of the Prior Art:

[0002] Above-mentioned type of combustor in the prior art will be outlined below with reference to Figs. 2 to 5. Fig. 4 is an entire constructional view of one example of a premixed flame type low NO_x combustor in the prior art and Fig. 5 is a cross sectional view of a main fuel nozzle as part of the combustor of Fig. 4.

[0003] What is called a fuel supply nozzle for supplying fuel and air or mixture thereof into a combustor consists of a pilot fuel nozzle 204 for forming a flame portion in a cross sectional center of the combustor, a plurality of main fuel nozzles 202, each having an outer casing 206, arranged surrounding said pilot fuel nozzle 204 for forming a pre-mixed gas of fuel and air, etc.

[0004] In an upstream portion of each of the main fuel nozzles 202, there is provided a main swirler 201 surrounding the main fuel nozzle 202 and extending to a position of the outer casing 206.

[0005] And in a wall of body of the main fuel nozzle 202 on a downstream side of the main swirler 201, there are bored a plurality of nozzle holes 205 along a circumferential direction of the main fuel nozzle 202.

[0006] In the prior art combustor constructed as above, there are provided the main swirlers 201 in plural units and a pilot swirler 203 in a single unit at a center of the combustor, and combustion air is supplied through the plurality of main swirlers 201 and the pilot swirler 203 and fuel is supplied from the plurality of main fuel nozzles 202 and the pilot fuel nozzle 204.

[0007] In the main fuel nozzle 202, as shown in Fig. 5, the fuel is injected from the nozzle holes 205 bored in the wall of body of the main fuel nozzle 202 and is mixed with the air flowing on an outer periphery of the nozzle via the main swirler 201 to form a pre-mixed gas.

[0008] When the air flows through the main swirler 201, it is given a swirling angle by the main swirler 201 and this angle is governed by a fitting angle in which a swirler vane is fitted to a hub portion thereof relative to a center axis of the fuel nozzle.

[0009] In the prior art swirler, while there is seen such an example that the fitting angle of the swirler vane is changed and adjusted for changing the swirling angle, the swirler in actual use remains such that when the fitting angle of the swirler vane to the hub portion (hub portion fitting angle) is changed and adjusted, that hub portion fitting angle is maintained same as far as to a tip portion of the swirler vane and there is seen no more example of angle change.

[0010] As concrete examples of changing the hub portion fitting angle of the swirler vane, there are ones shown in Figs. 2 and 3.

[0011] That is, one example is that the hub portion fitting angle of a swirler vane 201a relative to a center axis C of the main fuel nozzle 202 is 25°, as shown in Fig. 2, wherein Fig. 2(a) is a view showing arrangement of a swirler relative to the fuel nozzle and Fig. 2(b) is a development of arrangement of swirler vanes.

[0012] Also, another example is that the hub portion fitting angle of a swirler vane 201b relative to the center axis C of the main fuel nozzle 202 is 45°, as shown in Fig. 3, wherein Fig. 3(a) is a view showing arrangement of a swirler relative to the fuel nozzle and Fig. 3(b) is a development of arrangement of swirler vanes.

[0013] In either of Figs. 2 and 3, air A supplied from upstream runs into the swirler vane 201a or 201b to form an outward swirling flow and fuel F of natural gas and the like is supplied into this swirling flow of air via nozzle holes 205 of the main fuel nozzle 202 to form a pre-mixture of the fuel F and the air A.

[0014] In the prior art swirler in which the hub portion fitting angle of the swirler vane 201b shown in Fig. 3 is 45°, because said angle is as large as 45°, shearing flow of the air A is strong, so that mixing of the fuel F and the air A is accelerated very favorably.

[0015] However, due to said strong shearing flow, there is formed a large stagnation point P at a tip portion of the main fuel nozzle 202, as shown by a hatched portion in Fig. 3(a), and if a back fire phenomenon once occurs, flame stagnates at the stagnation point P, so that there arises a problem that the main fuel nozzle 202 is apt to burn.

[0016] On the other hand, in the prior art swirler in which the hub portion fitting angle of the swirler vane 201a shown in Fig. 2 is 25°, because said angle of 25° is comparatively small, shearing flow of the air A is not so strong and the stagnation point P which is formed at the tip portion of the main fuel nozzle 202, as shown by a hatched portion in Fig. 2(a), is small, hence even if a back fire phenomenon occurs, flame does not specifically stagnate there.

[0017] However, this effect is obtained by the shearing flow of the air A which is not very strong and as a result reversely, mixing of the fuel F and the air A, which is a function required for a pre-mixed type combustor, becomes worse, as clearly understood when compared with the swirler of Fig. 3 in which the hub portion fitting angle of the swirler vane 201b is 45° and there is a problem of narrow range of condition within which a low NO_x combustion is attained.

SUMMARY OF THE INVENTION:

[0018] It is therefore an object of the present invention to provide a swirler which is able to accelerate mixing of fuel and air as well as to make a stagnation point formed

at a tip portion of a main fuel nozzle smaller to thereby prevent occurrence of flame stagnation and burning of components so as to dissolve problems in the prior art.

[0019] In order to attain said object, the present invention provides a three-dimensional swirler characterized in that a swirler vane fitted around a fuel nozzle is twisted from a hub side thereof to a tip side thereof so that a fitting angle of the tip side relative to a center axis of the fuel nozzle is larger than that of the hub side.

[0020] That is, in the swirler vane fitted around the fuel nozzle, the swirler vane is twisted from the hub side to the tip side so as to change the fitting angle relative to the center axis of the fuel nozzle and said angle of the tip side is formed larger than that of the hub side. Thus, while said angle of the hub side is set to a smaller angle so that flame stagnation, and burning of components resulted therefrom, may be prevented from occurring, the swirler vane is twisted so that said angle of the tip side may be selected to an angle in which shearing flow necessary for appropriate mixing of fuel and air is obtained, thereby such a three-dimensional swirler as is able to make a favorable pre-mixing, to prevent a life deterioration due to the burning etc. and to enhance a combustion efficiency is obtained.

[0021] Also, the present invention provides a three-dimensional swirler as mentioned above, characterized in that in said swirler vane, the fitting angle of the hub side relative to the center axis of the fuel nozzle is 25° and that of the tip side is 45°.

[0022] That is, the fitting angle of the hub side relative to the center axis of the fuel nozzle is set to 25° in which flame stagnation and burning of components do not occur and said angle of the tip side is set to 45° in which shearing flow becomes strong, thus occurrence of problem of flame stagnation and burning on the hub side is restrained and strong shear flow on the tip side is secured, thereby such a three-dimensional swirler as is able to make a favorable pre-mixing of fuel and air, to prevent a life deterioration due to the burning etc. and to enhance a combustion efficiency is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0023]

Fig. 1 is a view showing one embodiment according to the present invention, wherein Fig. 1(a) is a view showing arrangement of a swirler relative to a fuel nozzle, Fig. 1(b) is a development of arrangement of swirler vanes and Fig. 1(c) is a perspective view of one of the swirler vanes.

Fig. 2 is a view of one example of swirler in the prior art, wherein Fig. 2(a) is a view showing arrangement of a swirler relative to a fuel nozzle and Fig. 2(b) is a development of arrangement of swirler vanes.

Fig. 3 is a view of another example of swirler in the prior art, wherein Fig. 3(a) is a view showing arrangement of a swirler relative to a fuel nozzle and Fig. 3(b) is a development of arrangement of swirler vanes.

Fig. 4 is an entire constructional view showing one example of a pre-mixed flame type low NO_x combustor in the prior art.

Fig. 5 is a cross sectional view of a main fuel nozzle as part of the combustor of Fig. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[0024] One embodiment according to the present invention will be described with reference to Fig. 1. Fig. 1 shows a three-dimensional swirler of an embodiment of the present invention, wherein Fig. 1(a) shows arrangement of a swirler relative to a fuel nozzle, Fig. 1(b) is a development of arrangement of swirler vanes and Fig. 1(c) is a perspective view of one of the swirler vanes.

[0025] In the present embodiment, a main swirler 101 is provided around a main fuel nozzle 102 and there are bored a plurality of nozzle holes 105 in a wall of the main fuel nozzle 102 along a circumferential direction thereof at position downstream of the main swirler 101, so that fuel F injected from the nozzle holes 105 mixes with air A which has passed through the main swirler 101 to form so-called a pre-mixture, and this basic concept and structure of swirler is same as that of the described prior art one.

[0026] The present embodiment is featured in that said main swirler 101 is constructed in a specific form as follows:

[0027] That is, as shown in Figs. 1(b) and (c), a fitting angle α of a swirler vane 101a on a hub side thereof is 25° relative to a center axis C of the main fuel nozzle 102 and a fitting angle β of the swirler vane 101a on a tip side thereof is 45° likewise relative to the center axis C of the main fuel nozzle 102.

[0028] Thus, as understood from Fig. 1(c), the swirler vane 101a is twisted from the hub side to the tip side by a differential angle between the hub side angle $\alpha = 25°$ and the tip side angle $\beta = 45°$.

[0029] In the present embodiment constructed as above, while the air A is changed of its flow direction by the swirler vane 101a of the main swirler 101, because the fitting angle α on the hub side of the swirler vane 101a is 25°, a stagnation point P, if formed, at a tip portion of the main fuel nozzle 102 is not so large.

[0030] Also, the swirler vane 101a is twisted from the hub side to the tip side and the fitting angle β on the tip side of the swirler vane 101a is 45°, hence there can be formed a strong shear flow there.

[0031] And the fuel F of natural gas and the like is supplied into a swirling flow of the air A so formed via the nozzle holes 105 bored in the main fuel nozzle 102 and a pre-mixture of the fuel F and the air A is formed.

[0032] Thus, according to the present embodiment,

the fitting angle on the hub side of the swirler vane 101a is set to 25° so that the stagnation point at the tip portion of the main fuel nozzle 102 is small and no substantial flame stagnation occurs there even if a back fire occurs, hence there is no fear of burning of components as well.

[0033] Also, the fitting angle on the tip side of the swirler vane 101a is set to 45° so that the shear flow of the air A on an outer side in a radial direction of the swirler is strong and mixing of the fuel F and the air A is accelerated, hence an excellent pre-mixture can be obtained.

[0034] The invention has been described with respect to the embodiment as illustrated, but it is not limited to such embodiment but, needless to mention, may be added with various modifications as come within the scope of the claims as set forth below.

Claims

1. A three-dimensional swirler, characterized in that a swirler vane (101a) fitted around a fuel nozzle (102) is twisted from a hub side thereof to a tip side thereof so that a fitting angle (β) of the tip side relative to a center axis (C) of the fuel nozzle (102) is larger than that (α) of the hub side.

2. A three-dimensional swirler as claimed in Claim 1, characterized in that in said swirler vane (101a), the fitting angle (α) of the hub side relative to the center axis (C) of the fuel nozzle (102) is 25° and that (β) of the tip side is 45°.

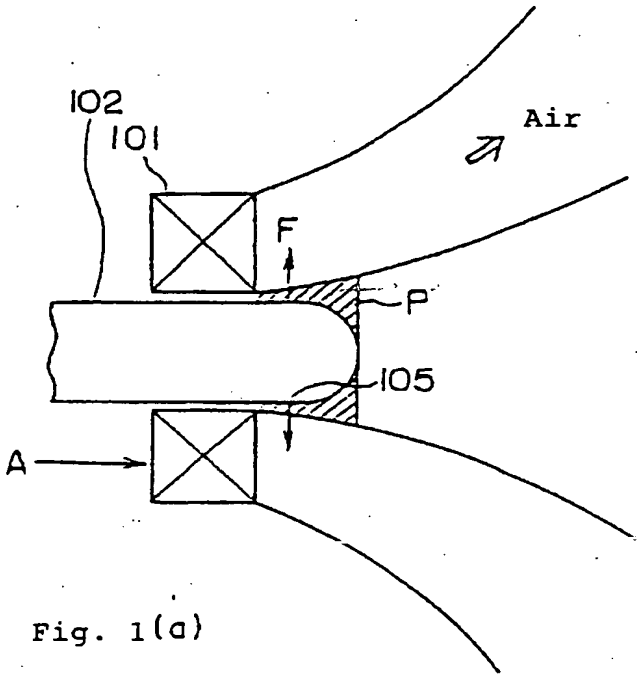


Fig. 1(a)

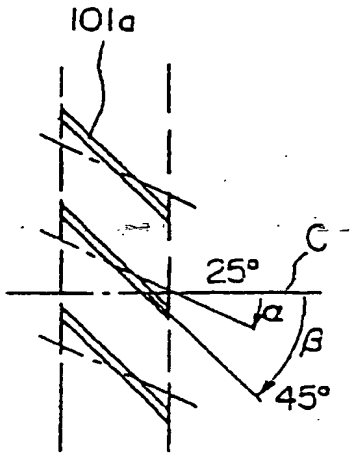


Fig. 1(b)

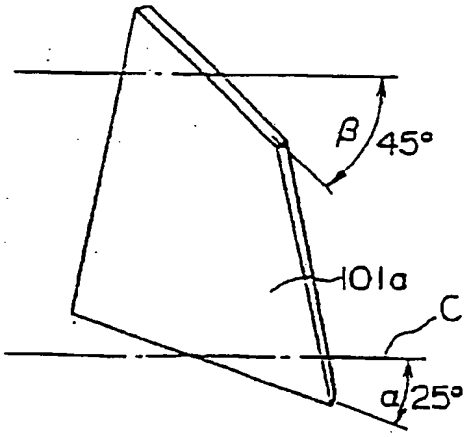


Fig. 1(c)

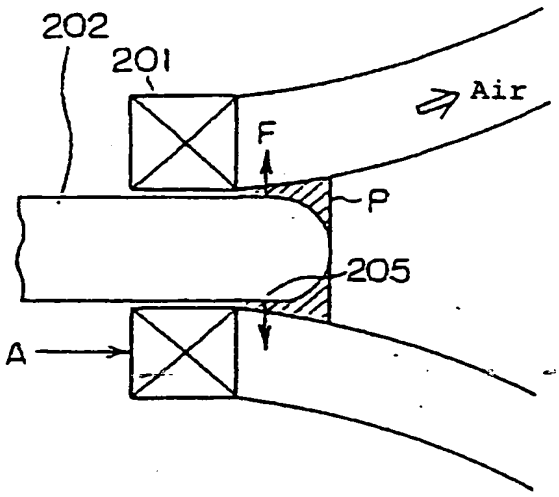


Fig. 2 (a)

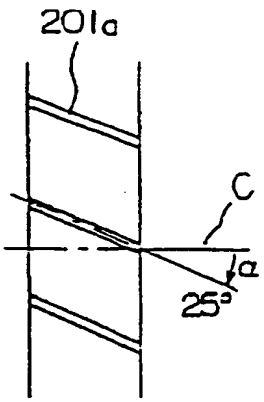


Fig. 2 (b)

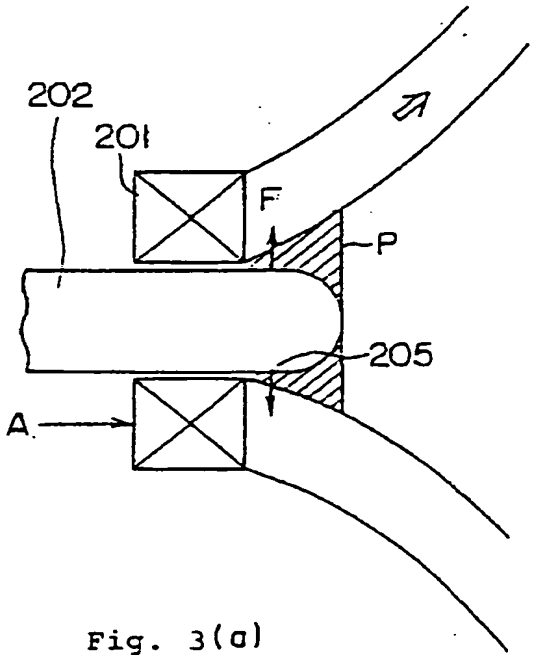


Fig. 3(a)

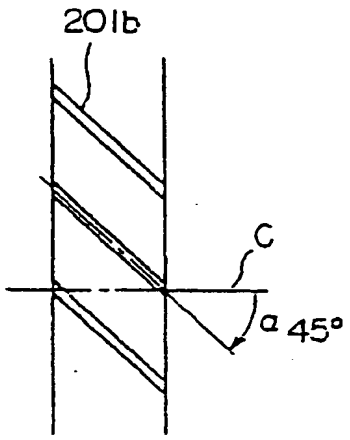


Fig. 3 (b)

Fig. 4

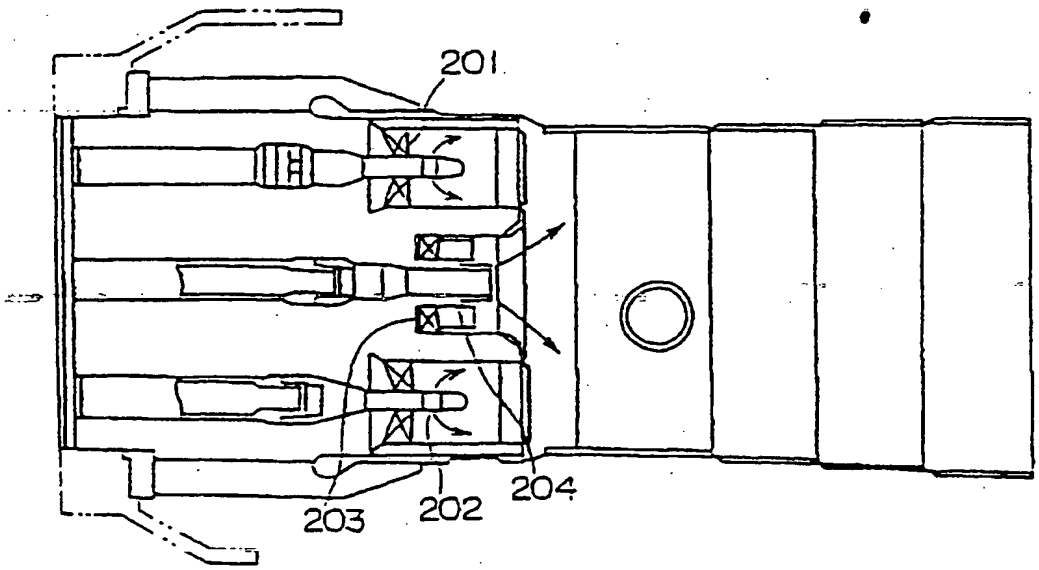
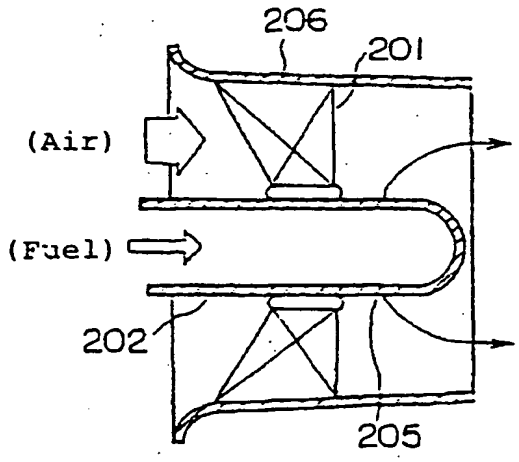


Fig. 5



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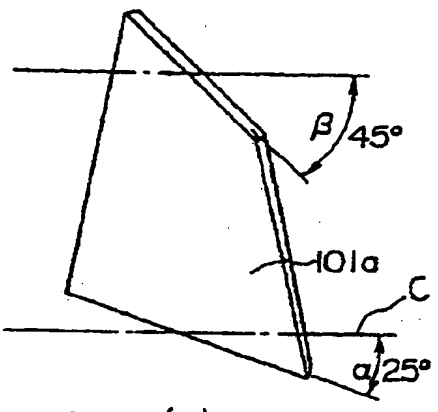

Fig. 1(c)

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EUROPEAN SEARCH REPORT

Application Number
EP 98 11 6591

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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X	US 4 221 558 A (SANTISI HARRY C) 9 September 1980 (1980-09-09) * figure 1 *	1	
A	EP 0 397 046 A (MITSUBISHI HEAVY IND LTD) 14 November 1990 (1990-11-14) * column 2, line 51 - column 3, line 2 *	1,2	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 July 2000	Steinhauser, U

CATEGORY OF CITED DOCUMENTS

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